Albedo Trends: Cloud Properties and Aerosols

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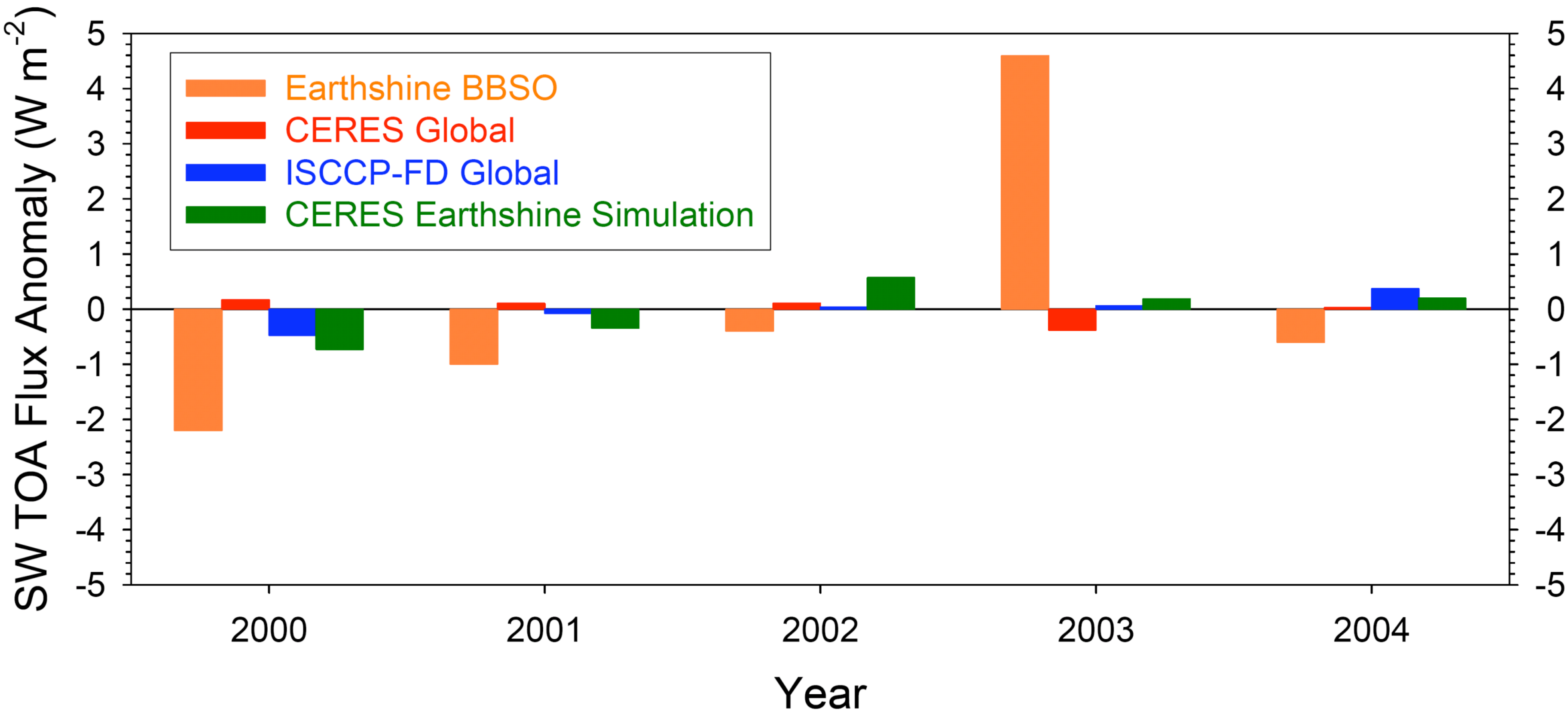
Oct 26th, 2006, CERES STM (Exeter, UK)

INTRODUCTION

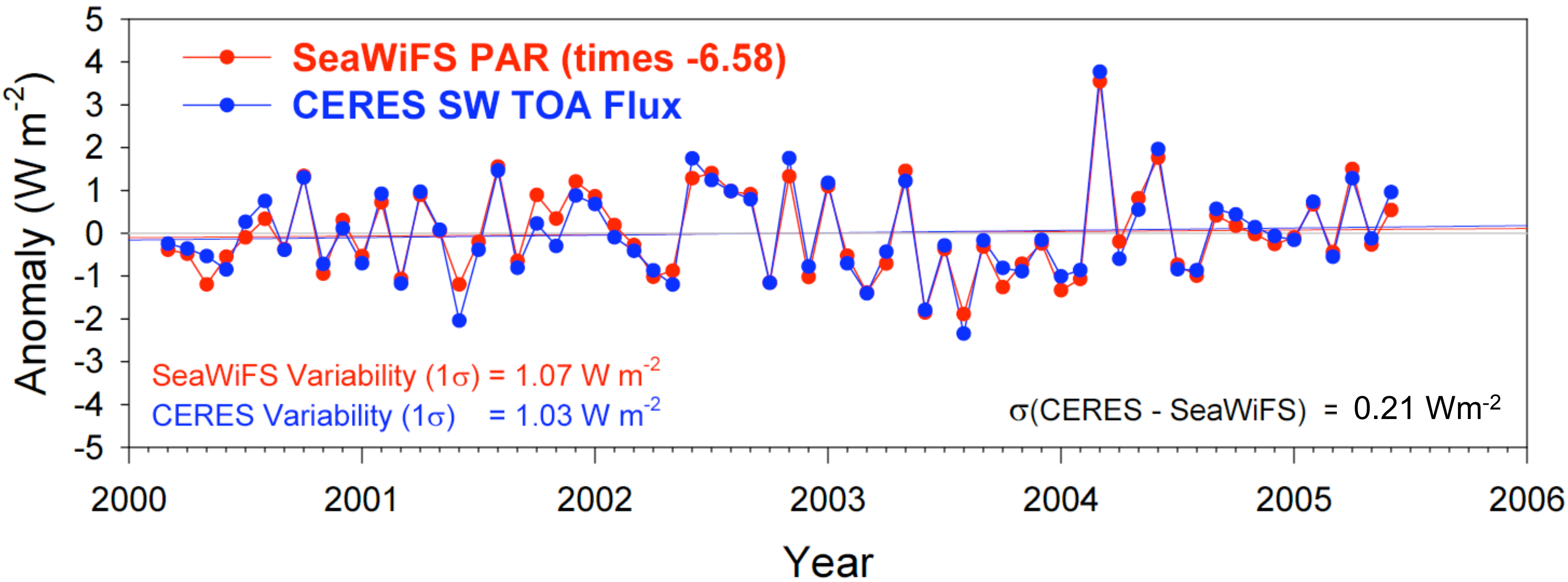
- SW TOA flux anomalies between 2000-2005
- Seasonal cycle in global and hemispheric albedo
- Cloud radiative forcing by cloud type
- Anomalies in aerosol direct radiative effect

Annual Mean Global SW TOA Flux Anomaly



Loeb et al. 2006
GRL, submitted

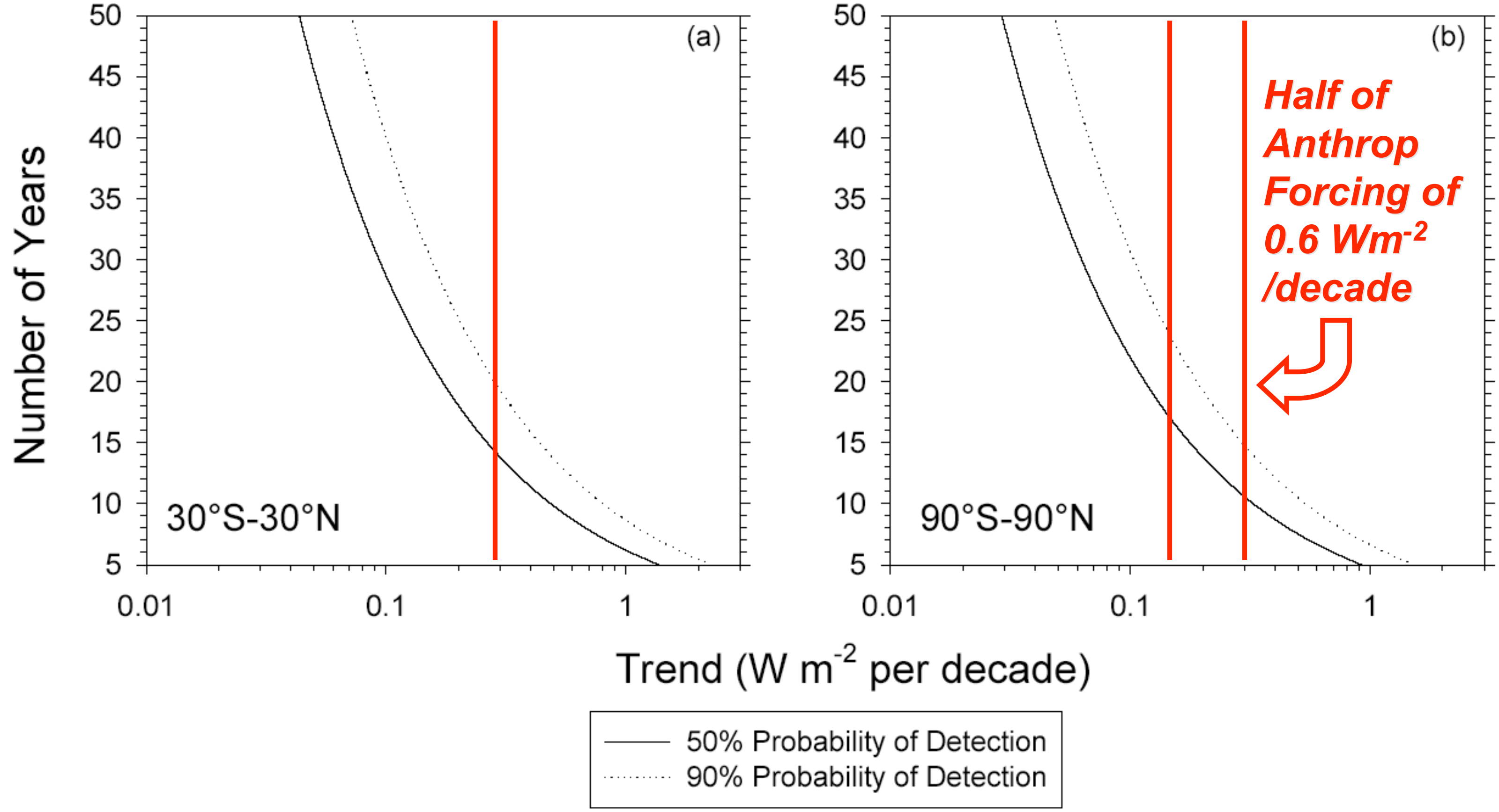
SeaWiFS PAR and CERES FM1 Ed2B_rev1 SW TOA Flux Anomaly (Ocean; 30°S-30°N)



Shows consistent calibration stability at < 0.3 Wm^{-2} per decade (95% conf)
Unfortunately only works for tropical mean ocean (nband vs bband issues)
Regional trends differ by +2 to -5 Wm^{-2}/decade SeaWiFS vs CERES

Loeb et al. 2006
J. Climate, in press

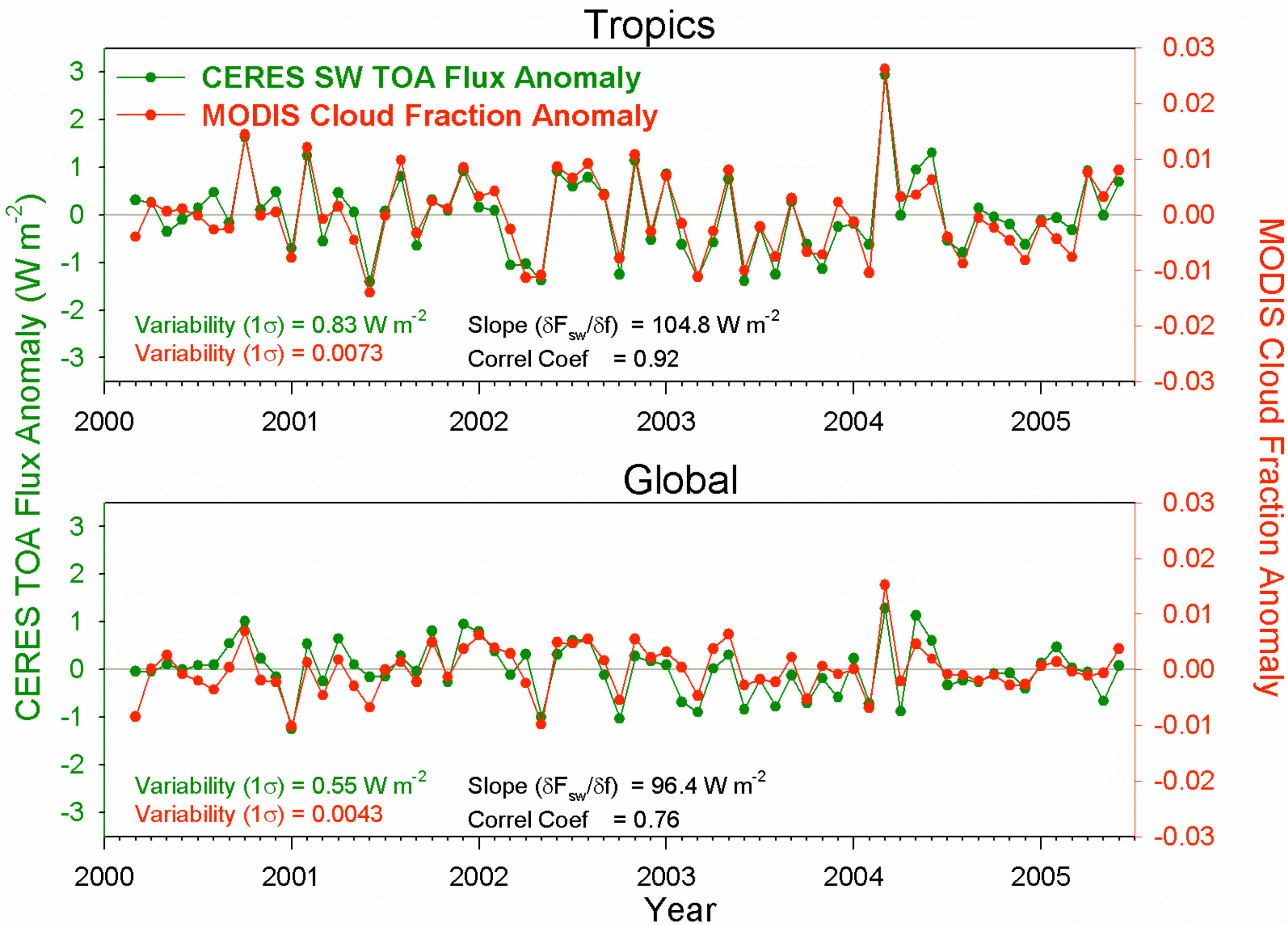
Using CERES to Determine Length of Climate Data Record Needed to Constrain Cloud Feedback



Given climate variability, 15 to 20 years is required to first detect climate trends at cloud feedback level with 90% confidence, and 18 to 25 years to constrain to +/- 25% in climate sensitivity

Loeb et al. 2006
J. Climate, in press

CERES Shortwave TOA Reflected Flux Changes: Ties to Changing Cloud Fraction



Unscrambling climate signal cause and effect requires complete parameter set at climate accuracy, e.g. for forcing/response energetics: radiation, aerosol, cloud, land, snow/ice, temperature, humidity, precipitation

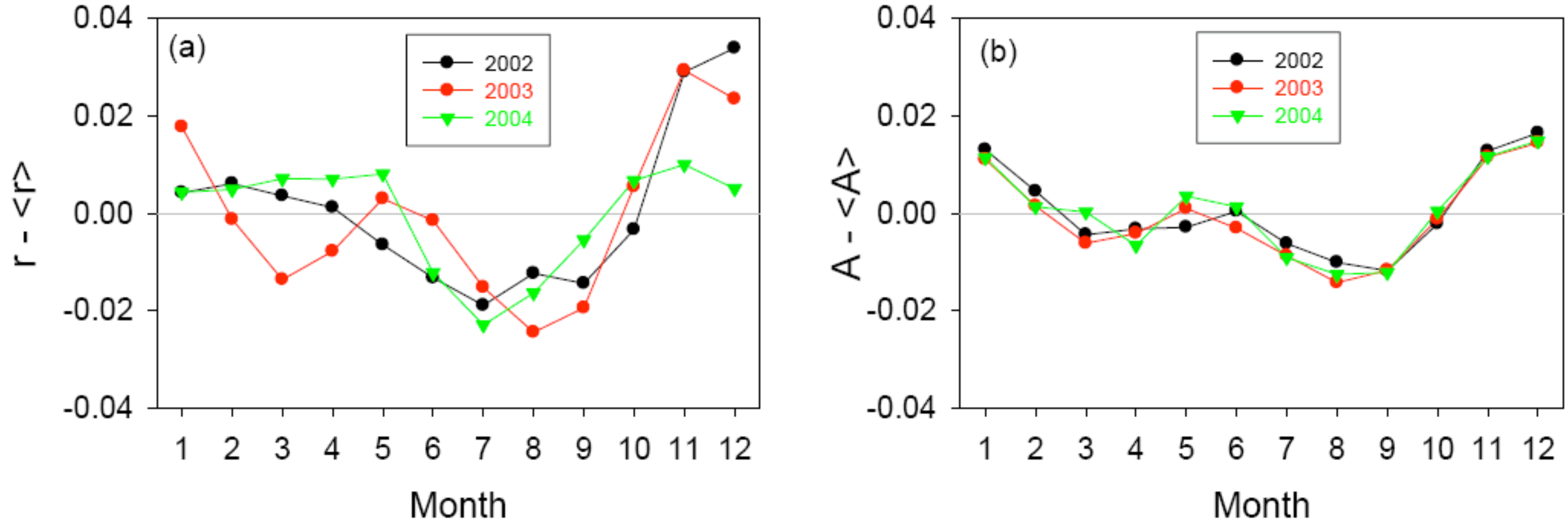
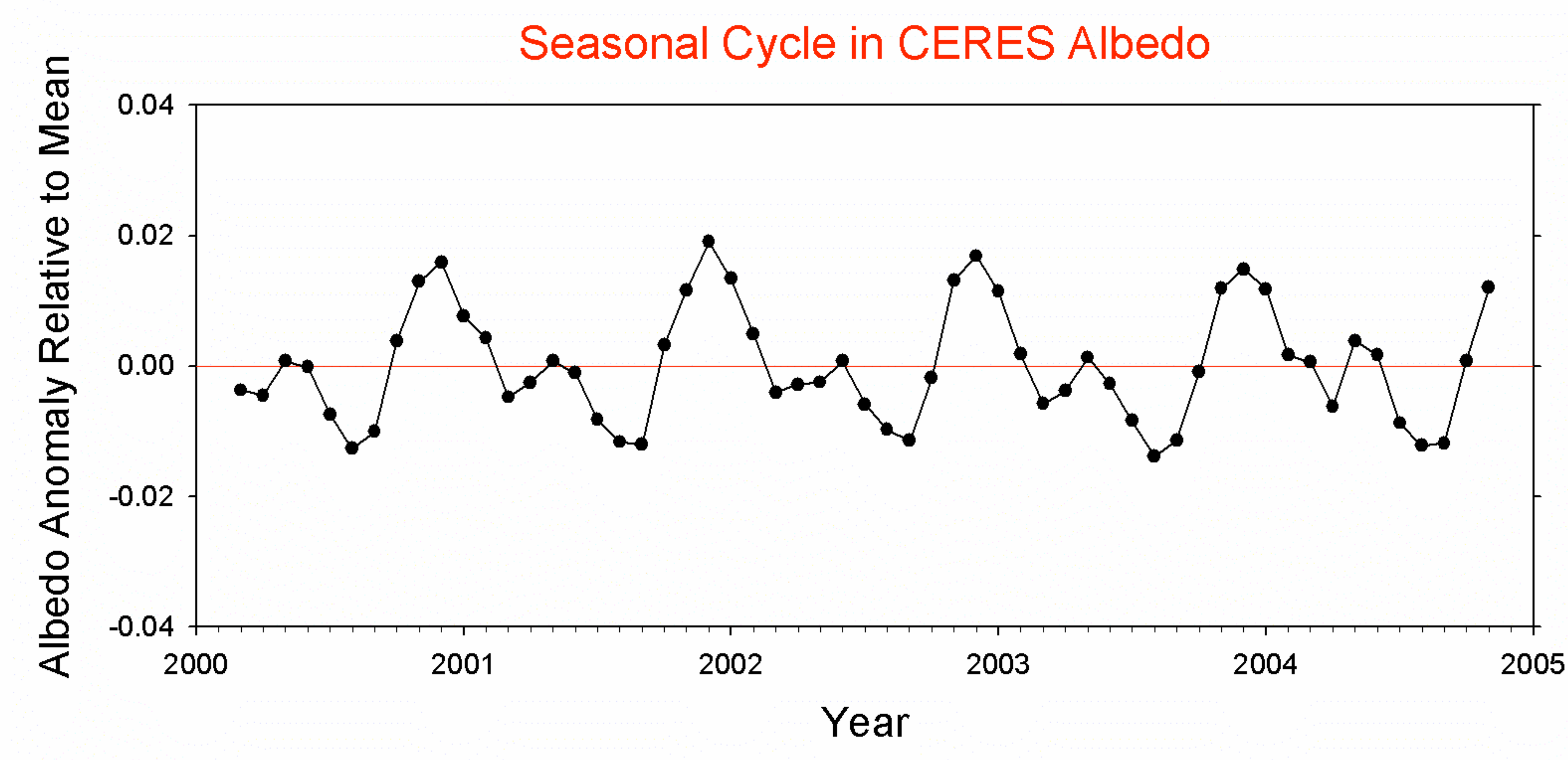
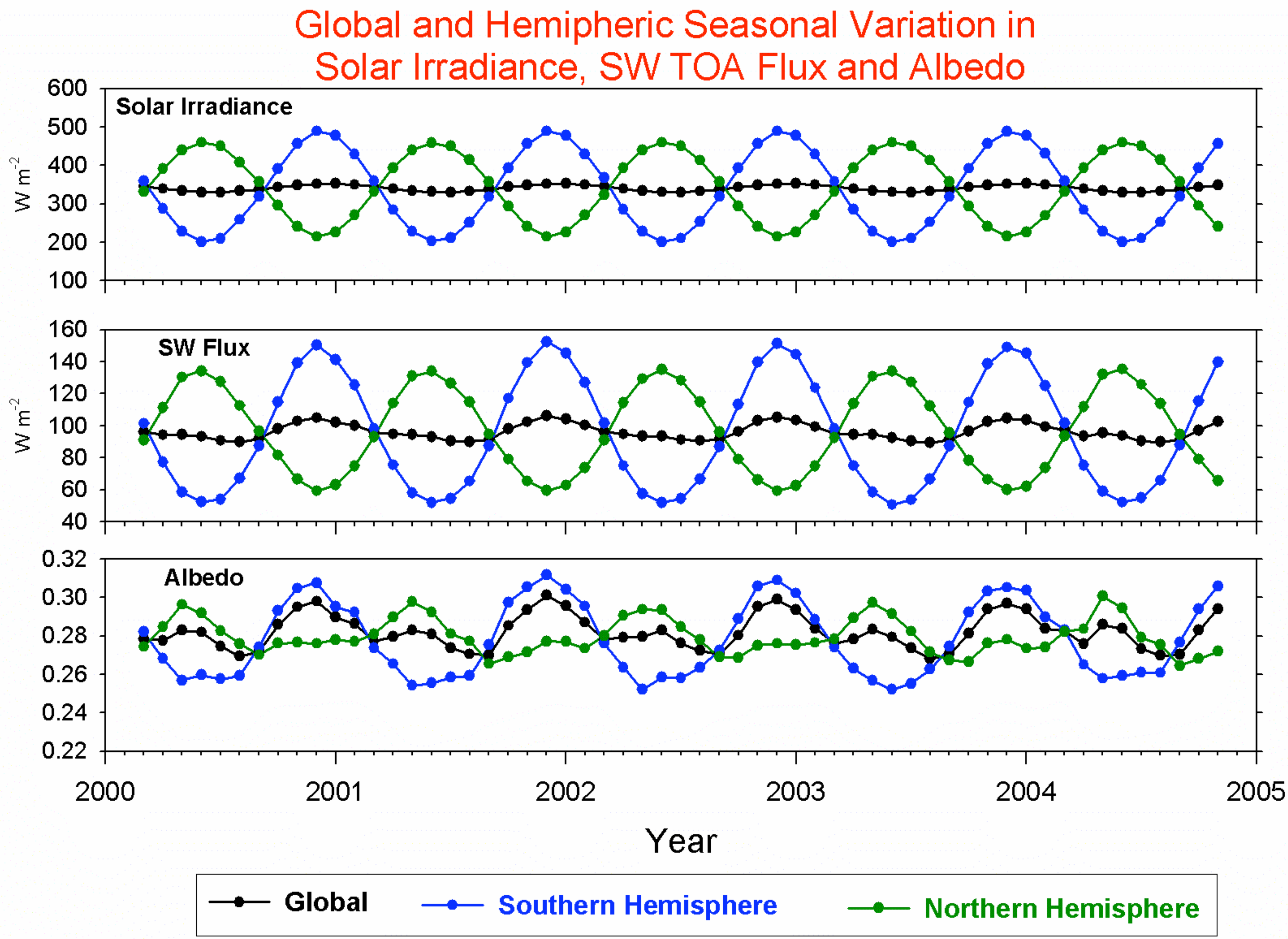


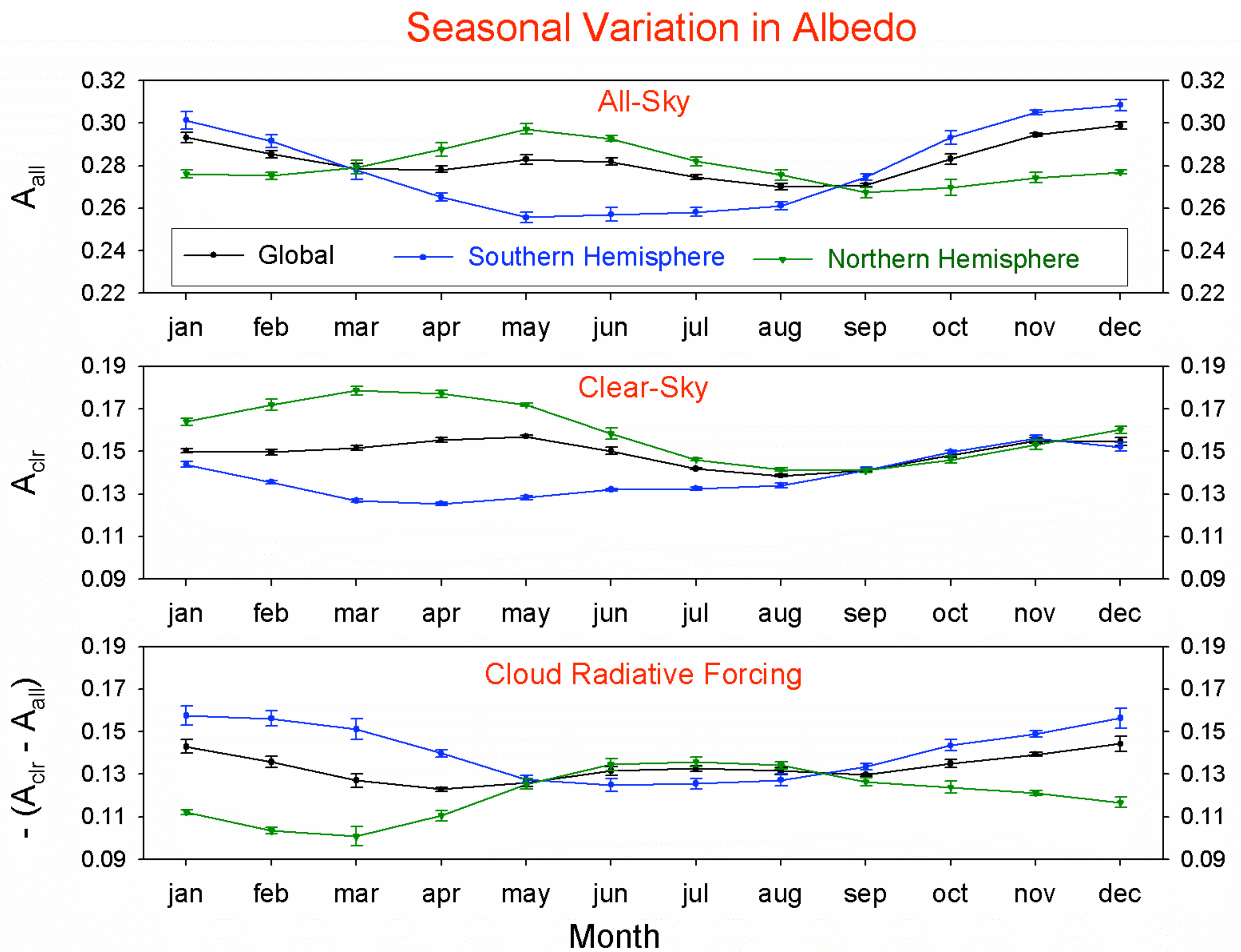
Figure 1 Seasonal variation in (a) simulated Earthshine reflectance and (b) CERES global albedo expressed as the deviation from the 3-year mean value. Earthshine reflectances are adjusted to a common lunar phase angle of 95°.

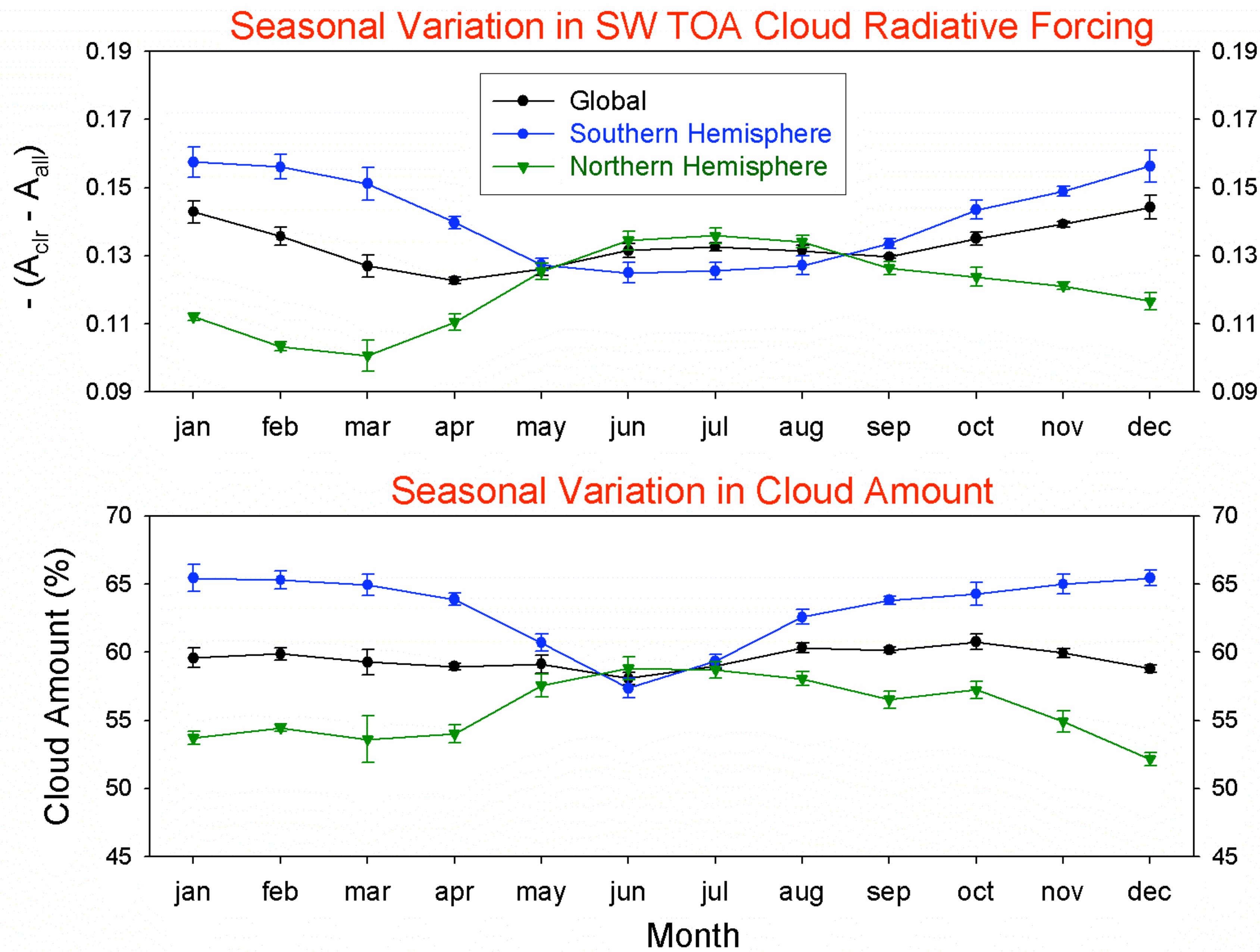


Seasonal Cycle in CERES Albedo
Albedo Anomaly Relative to Mean
0.04
0.02
0.00
-0.02
-0.04
2000
2001
2002
2003
2004
2005
Year

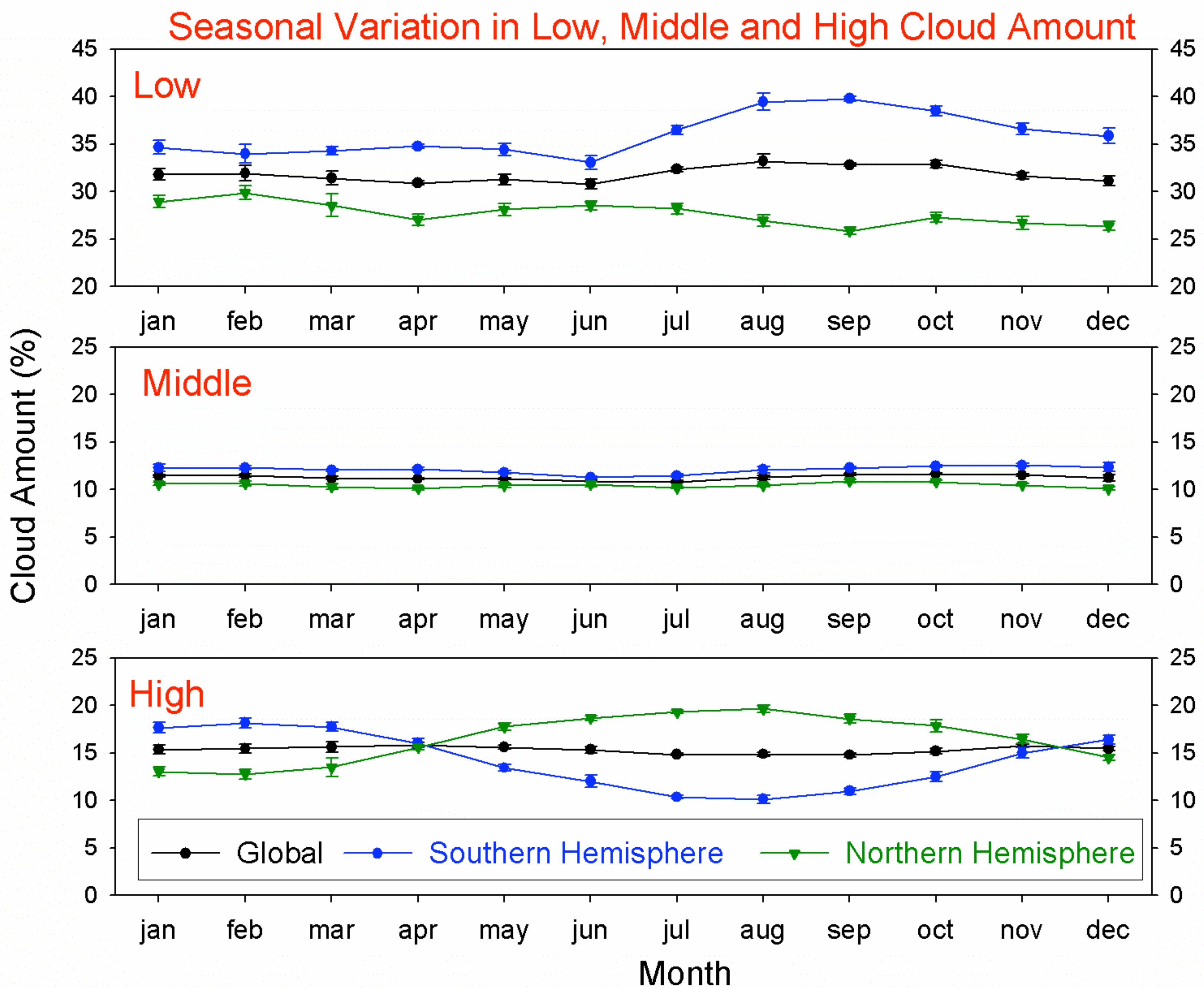


Global and Hemipheric Seasonal Variation in
Solar Irradiance, SW TOA Flux and Albedo
Solar Irradiance
SW Flux
Albedo
W m-2
Year
2000
2001
2002
2003
2004
2005
Global
Southern Hemisphere
Northern Hemisphere

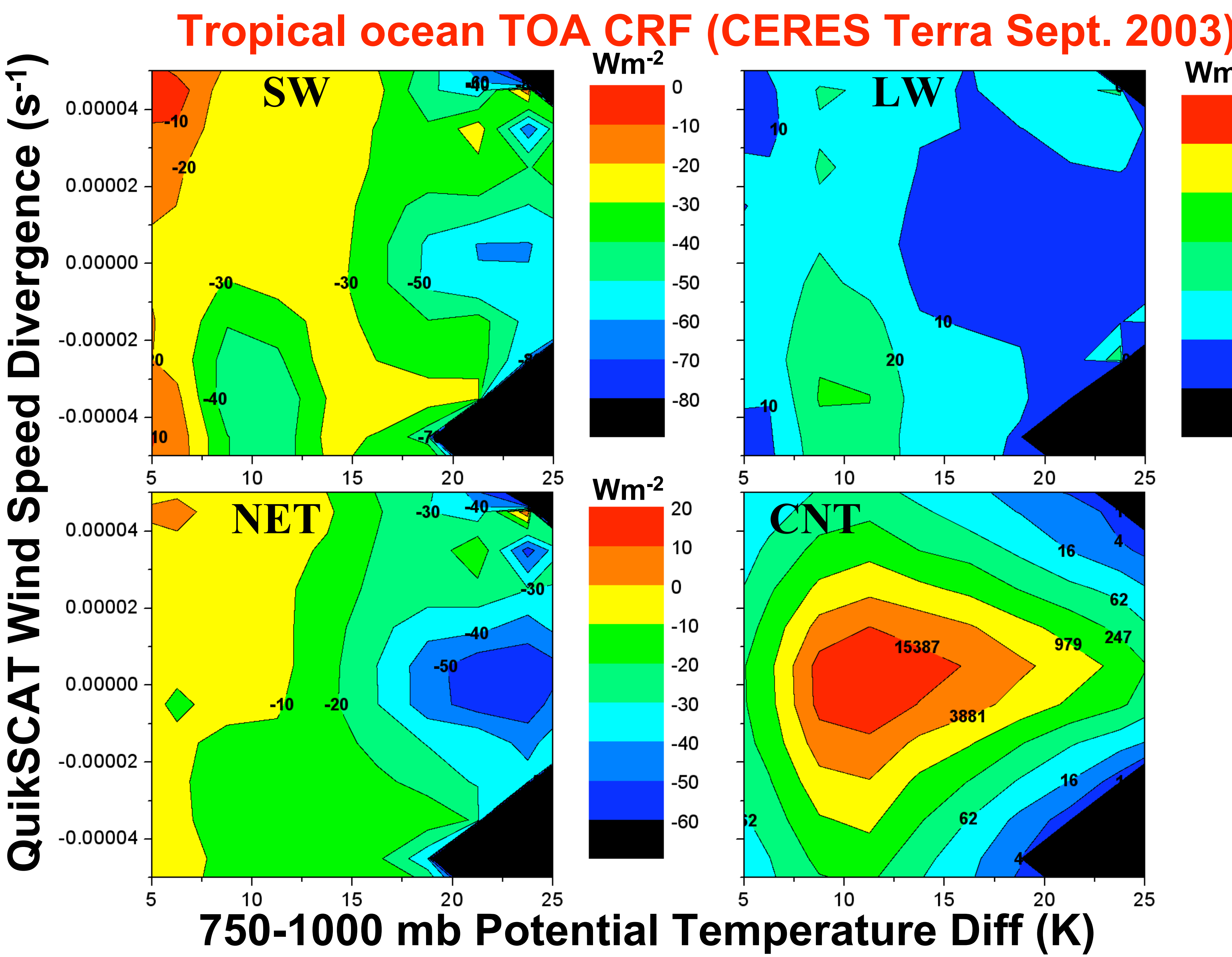

Seasonal Variation in Albedo
All-Sky
A_{all}
Global
Southern Hemisphere
Northern Hemisphere
0.22
0.24
0.26
0.28
0.30
0.32
jan feb mar apr may jun jul aug sep oct nov dec
Clear-Sky
A_{clr}
0.09
0.11
0.13
0.15
0.17
0.19
jan feb mar apr may jun jul aug sep oct nov dec
Cloud Radiative Forcing
$-(A_{clr} - A_{all})$
0.09
0.11
0.13
0.15
0.17
0.19
jan feb mar apr may jun jul aug sep oct nov dec
Month



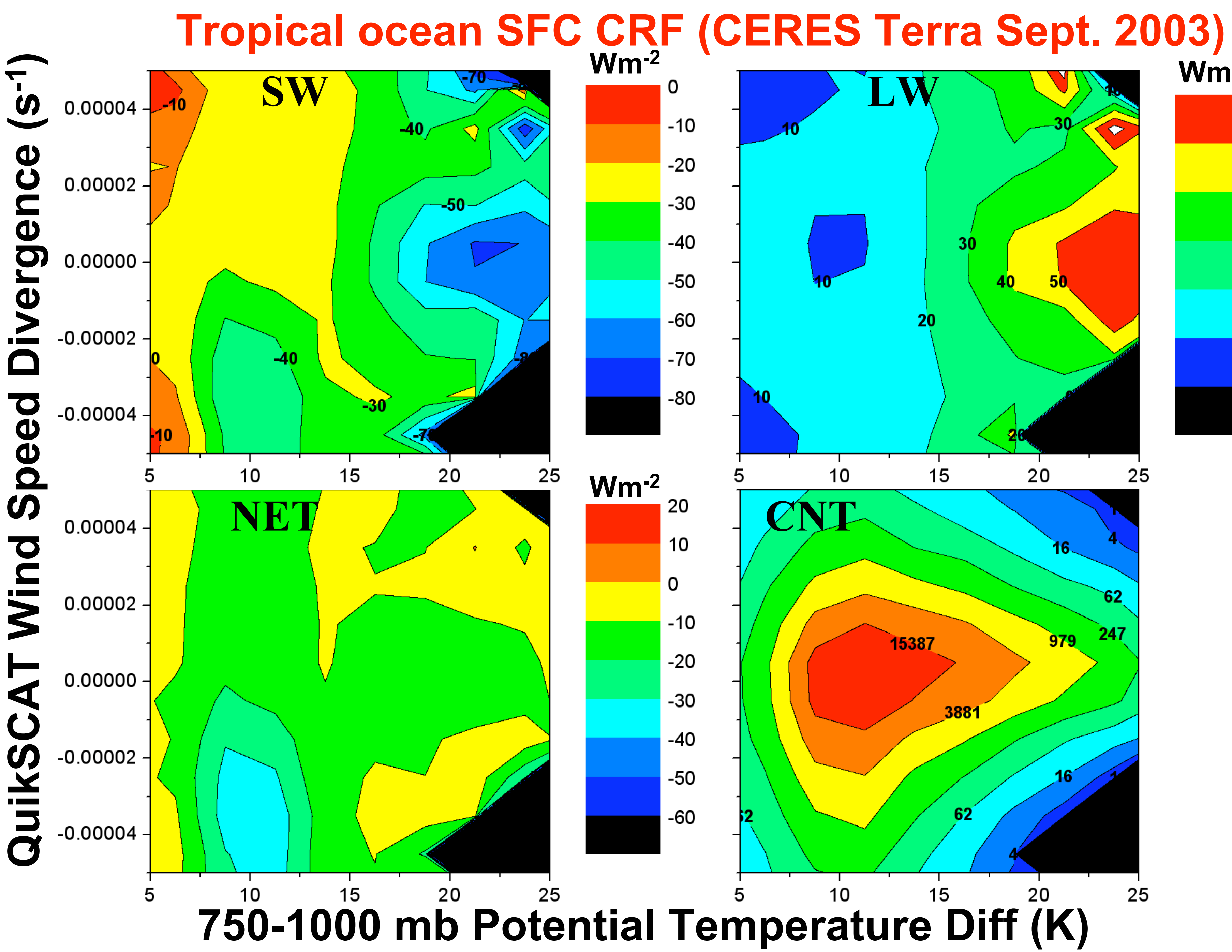
Seasonal Variation in SW TOA Cloud Radiative Forcing
- (A_clr - A_all)
0.19
0.17
0.15
0.13
0.11
0.09
Global
Southern Hemisphere
Northern Hemisphere
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
Seasonal Variation in Cloud Amount
Cloud Amount (%)
70
65
60
55
50
45
Month



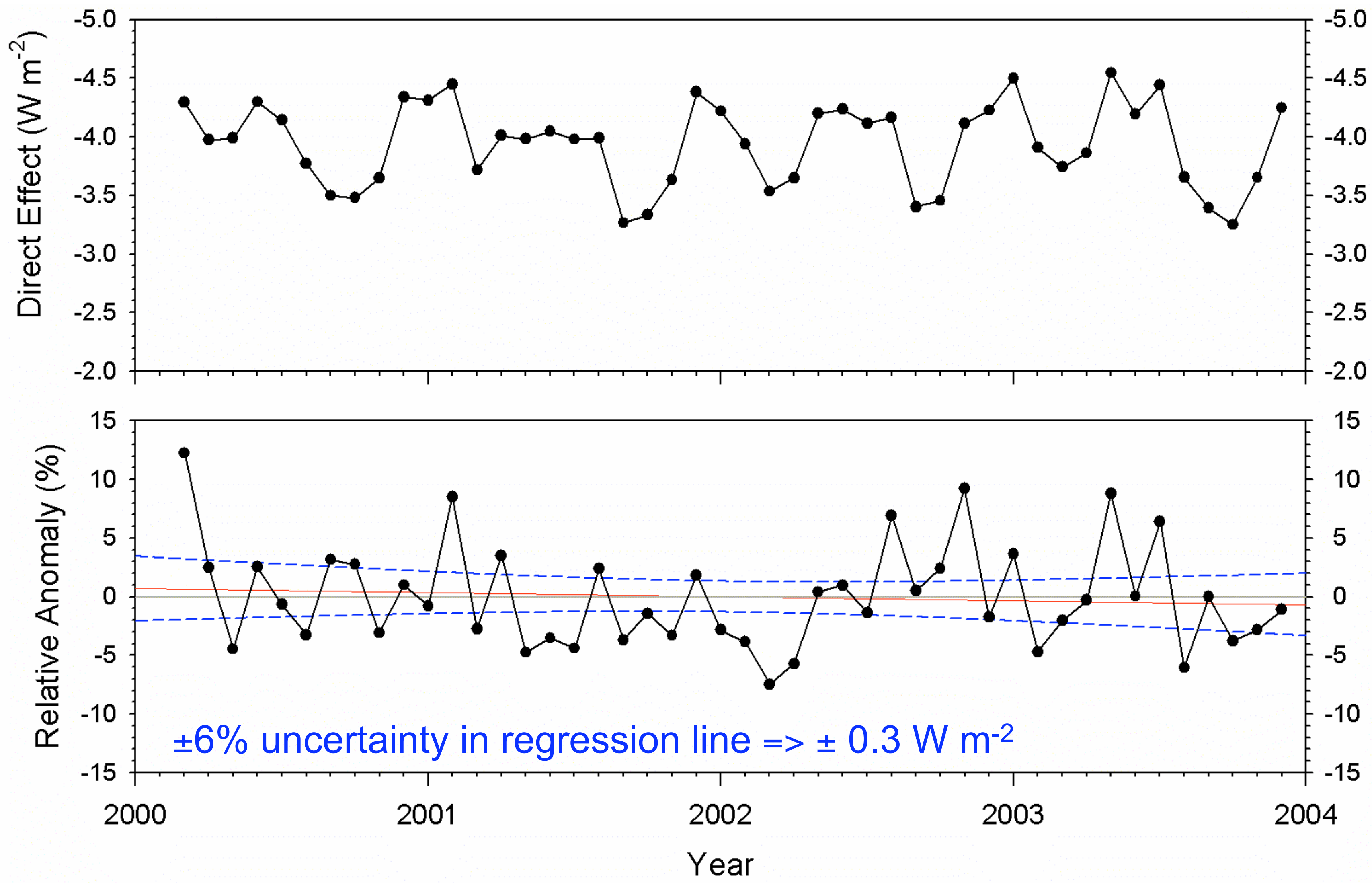
Seasonal Variation in Low, Middle and High Cloud Amount
Low
Middle
High
Cloud Amount (%)
Month
jan feb mar apr may jun jul aug sep oct nov dec
Global
Southern Hemisphere
Northern Hemisphere



Tropical ocean TOA CRF (CERES Terra Sept. 2003)
SW
LW
NET
CNT
Wm-2
QuikSCAT Wind Speed Divergence (s-1)
750-1000 mb Potential Temperature Diff (K)


Tropical ocean SFC CRF (CERES Terra Sept. 2003)
SW
LW
NET
CNT
Wm-2
QuikSCAT Wind Speed Divergence (s-1)
750-1000 mb Potential Temperature Diff (K)

SW Direct Radiative Effect of Aerosols
Clear Ocean (30°S-30°N)



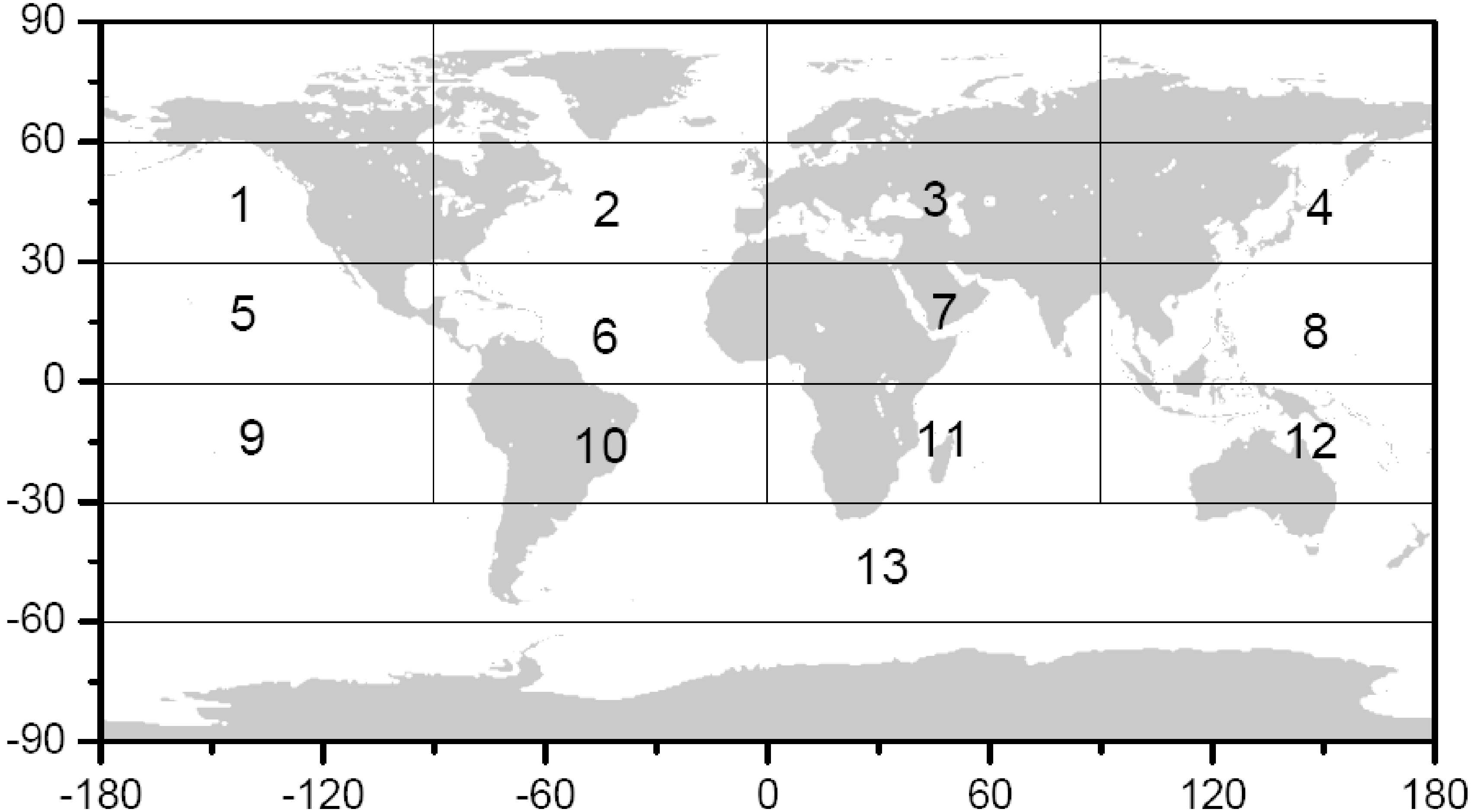
Aerosol Effect on Clear Ocean Variability

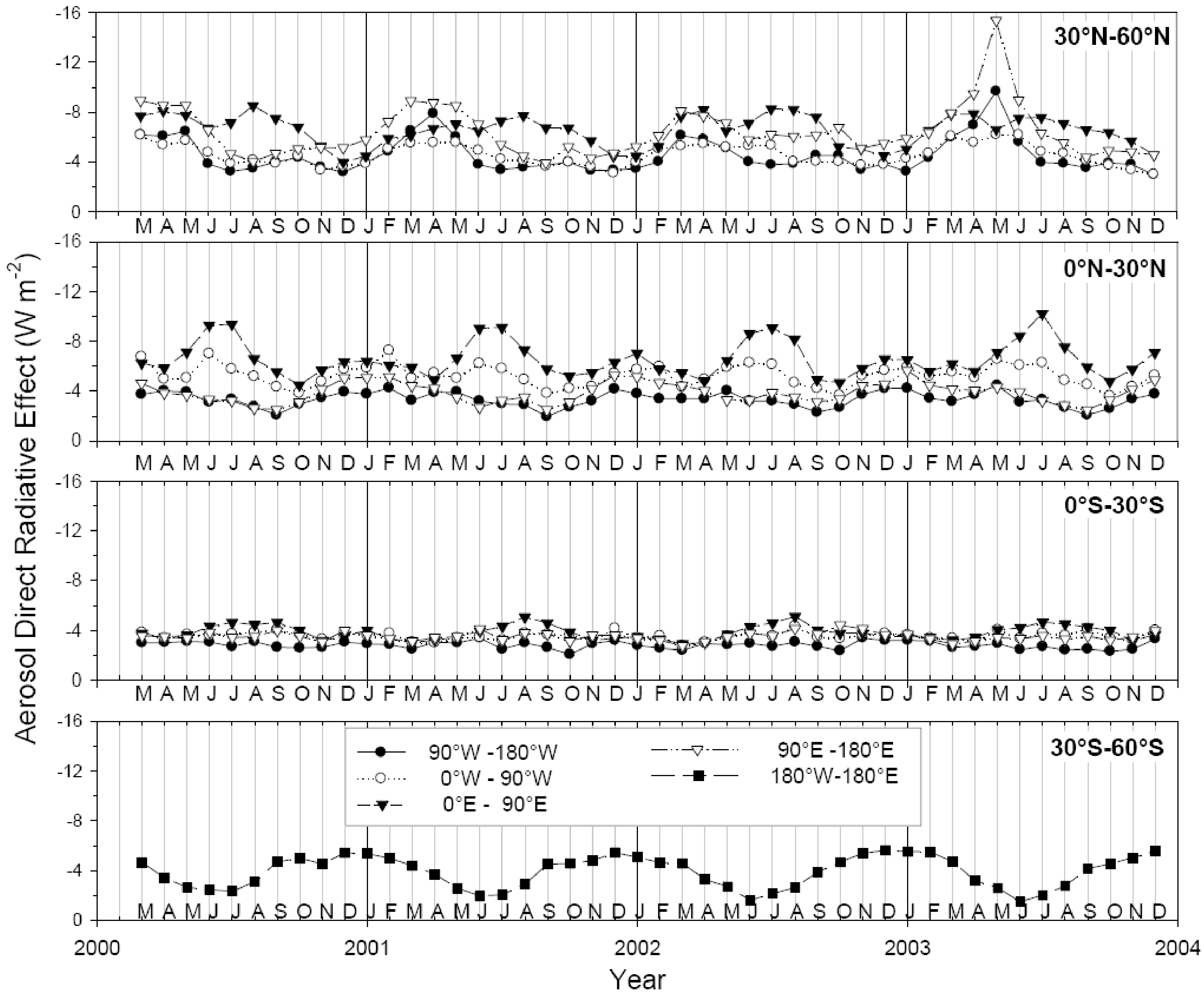
- The uncertainty in aerosol direct radiative effect change over 4 years is ±6% or ± 0.3 W m^{-2}

- Typical clear ocean TOA flux ~ 40 W m^{-2}

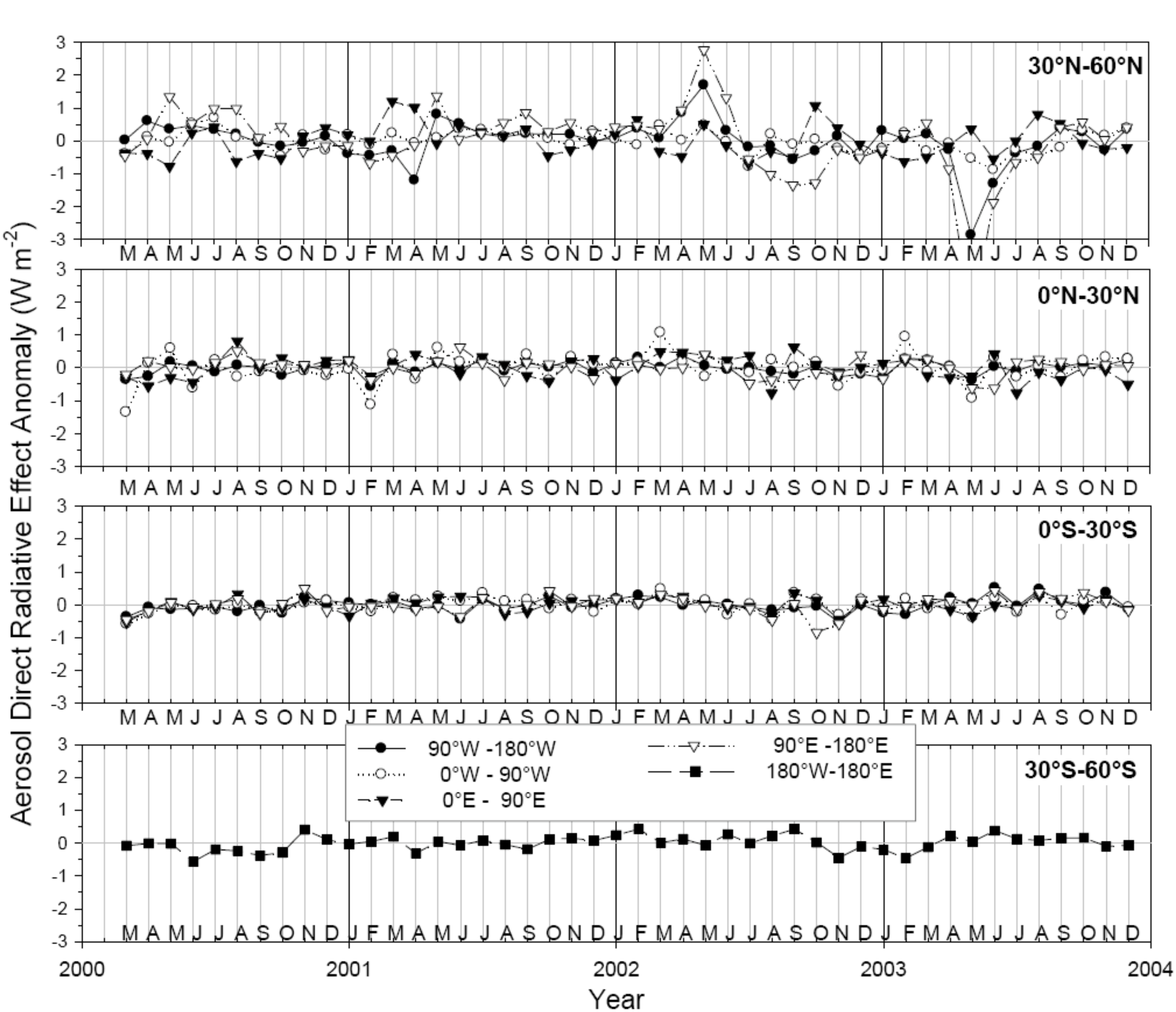
$\Rightarrow$ Maximum expected change in clear ocean SW TOA flux from by aerosol variability alone is:

±0.3 / 40 x 100% = ± 0.75% (over 4 years)


90
60
30
0
-30
-60
-90
-180
-120
-60
0
60
120
180
1
2
3
4
5
6
7
8
9
10
11
12
13



30°N-60°N
0°N-30°N
0°S-30°S
30°S-60°S
Aerosol Direct Radiative Effect (W m-2)
90°W -180°W
0°W - 90°W
0°E - 90°E
90°E -180°E
180°W-180°E
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
-16
-12
-8
-4
0
2000
2001
2002
2003
2004
Year


30°N-60°N
0°N-30°N
0°S-30°S
30°S-60°S
Aerosol Direct Radiative Effect Anomaly (W m-2)
90°W -180°W
0°W - 90°W
0°E - 90°E
90°E -180°E
180°W-180°E
Year
2000
2001
2002
2003
2004

SUMMARY

- No significant trend in SW TOA flux anomalies between 2000-2005 (despite what Earthshine says…).
- Consistency between CERES SW TOA flux and SeaWiFS PAR ~0.3 Wm^{-2} per decade based on first 5 yrs of CERES.
- ~15 to 20 years is required to first detect climate trends at cloud feedback level with 90% confidence.
- Distinct patterns in seasonal cycle of global and hemispheric all-sky and clear-sky TOA albedo: can GCMs reproduce CERES results?
- Cloud radiative forcing by dynamic state: useful metric for testing climate models?
- No significant trend in SW direct radiative effect of aerosols but large interannual variability over Pacific Ocean between 30°N-60°N due to Asian dust.